התפשטות ופיזור גלים (0512.4862) - שנה״ל תשפ״א

PART I: RADIATION

1. Basic laws of electromagnetics – Review

2. Plane-waves

- 2.1. Plane-waves in a homogeneous medium
- 2.2. Polarization
- 2.3. Reflection and transmission
- 2.4. Evanescent waves
- 2.5. Waves in a stratified medium
- 2.6. Home projects: (a) A conducting medium - reflection and transmission; (b) A dielectric layer.

3. Radiation in free space

- 3.1. Vector potentials
- 3.2. Green's function
- 3.3. The elementary dipole: the near and far zones (the quasi static and the radiation zones)
- 3.4. Far field approximations (Fresnel and Fraunhofer): radiation pattern
- 3.5. Fourier space representation
- 3.6. Home projects: (a) Finite dipole antennas; (b) A uniform current sphere

4. Radiation from planar apertures

- 4.1. The equivalence theorem
- 4.2. Alternative field solutions
- 4.3. Far field approximations: Explicit expressions in terms of the Fourier transform of the aperture fields
- 4.4. Examples: Rectangular apertures - radiation pattern, beam width, spectral and spatial resolutions
- 4.5. Home projects: (a) rectangular aperture with linear phase; (b) scattering by metallic plates

5. Plane-wave spectrum analysis of radiation from planar apertures

- 5.1. Spectral wave equation
- 5.2. Propagating and evanescent spectra
- 5.3. The spectral integral
- 5.4. Asymptotic evaluation of the plane-wave integral in the far field:
- 5.5. A spectral derivation of the Green's function results in Section 4.4 and discussion.

PART II: SCATTERING

6. **Scattering: Integral representation**

- 6.1. Kirchhhoff theorem
- 6.2. Physical interpretation of Kirchhoff integral
- 6.3. Sommerfeld radiation condition
- 6.4. The scattering integral equations
- 6.5. 2D electromagnetics - E and H polarizations
- 6.6. Home project: Derivation of the 2D Green's function
- 6.7. Numerical solutions - method of moments; the current, the radiated field and the Radar cross section (RCS)
- 6.8. Exact Mie series solution for scattering by a circular cylinder.
- 6.9. Mid-term project 1: Plane wave scattering from conducting cylinders - comparison of the method of moment, the exact Mie series and the Physical Optics solutions for the current and for the RCS.

7. The Physical Optics approximation and asymptotic evaluations

- 7.1. Physical optics sources
- 7.2. Asymptotic evaluation of integrals: stationary-point and end-point contributions, uniform asymptotics for nearby stationary and end points
- 7.3. Example: PO solution for scattering by a conducting half plane - geometrical optics, edge diffraction, the field in the shadow transition region
- 7.4. Example: PO solution for scattering from a conducting cylinder - geometrical optics.

8. Radiation from apertures (aperture diffraction)

- 8.1. Kirchhoff integral
- 8.2. Rayleigh-Sommerfeld representation
- 8.3. Fraunhofer and Fresnel integrals
- 8.4. Thin lens formula; Introduction to Fourier Optics
- 8.5. Spectral formulation for Kirchhoff and Rayleigh-Sommerfeld representations

9. Gaussian beams

- 9.1. Radiation integral formulation
- 9.2. Parabolic equation formulation

PART III: PROPAGATION AND SCATTERING IN INHOMOGENEOUS MEDIA

10. Geometrical optics (GO) as an asymptotic solution of the wave equation

- 10.1. The wave equation in an inhomogeneous medium
- 10.2. Luneberg Kline series - asymptotic series solution
- 10.3. The Eikonal and transport equations
- 10.4. GO in inhomogeneous media: Wavefronts, rays and local plane waves. Ray tracking; ray curvature; Fermat principle. The transport equation and energy conservation. Polarization. Caustics
- 10.5. GO field in a uniform medium: caustics; wavefront curvature
- 10.6. Reflection and transmission at curved dielectric interfaces
- 10.7. GO approximation of RCS (Radar cross section).
- 10.8. Plane stratified medium
- 10.9. GO approximation for the Green's function in inhomogeneous medium

11. Geometrical Theory of Diffraction (GTD)

- 11.1. Basic rules
- 11.2. Edge diffraction (half-plane and wedges): plane-wave solutions
- 11.3. Comparison with PO solutions

12. Modal fields

- 12.1. Wave propagation in a guiding environment
- 12.2. The eigenvalue-eigenfunction problem
- 12.3. WKB approximation

<u>Final Home Project</u>: Solution of a complex scattering problem and/or of inhomogeneous waveguides.

<u>References:</u>

1. A. Ishimaru, "Electromagnetic wave propagation, radiation and scattering", Prentice-Hall, 1991.
2. R.F. Collin and F.J. Zuckor, "Antenna Theory", Vols.I and II, McGraw Hill, 1969. Chaps.2-3.
3. M. Born and E. Wolf, "Principles of Optics, Pergamon Press, Oxford.
4. G.L. James, "Geometrical theory of diffraction for electromagnetic waves", IEE Press, Series on EM waves, 3rd ed., 1986.
5. R. Mittra, Editor, "Numerical and asymptotic techniques in electromagnetics", Springer Verlag, Series on Topics in Applied Physics, Chap.6, The GTD and its applications, by R.G. Kouyoumjian.
6. R.G. Harrington, "Field computation by moment methods", Mcmillan Pub., 1986 and IEEE Press, 1993.